LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Effects of Lightning upon Electric Lamps.

THE accompanying effects were obtained when attempting photographs of lightning, and were rather the result of accident than design; an impending thunderstorm, with a somewhat limited horizon, prevented the camera from being pointed in the direction whence the most numerous of the lightning flashes occurred, without including in the field one or more of the electric arc lamps (Brush) which are the illuminating power of our town. Upon developing the few exposures made, it was noticed that whether or not the picture *took in* the flash, and in many cases this did not appear at all, there was exhibited upon the films the light of the permanent lamps, and that from them a flow of electricity proceeded towards the ground in an irregular line. Ground or summer lightning, as it is frequently called, produced the same effect upon the lamps, but when neither was present an exposed film only showed a sequence of white dots or perpendicular short strokes in the places occupied by the lamps, as seen by the naked eye at night. The result was sufficiently curious to invite further experiments in the same direction, but this could not be done upon the same lines as before, for the electric system varies with the months upon the sea front at Dover. In autumn, winter and spring the usual lighting is considered sufficient for all purposes, but during the visitors' season an additional illumination is provided by festoons of smaller glow lights from standard to standard, with occasional cross festoons over the roadway, the whole producing a charming effect at night; but, as will be seen in No. 6, the detail as to these becomes confused to any one not acquainted with the relative position of the lamps.

The first impression these photographs gave me was that the electric discharge in the heavens produced an instantaneous one also from the lamps, and that in this way the circuit was completed; but other causes beyond these must have been in action from the disjointed and irregular display from the lamps as opposed to that of the lightning.

Sir George Stokes, who has kindly interested himself in the matter, appends his views, and I need only add that I hope when a thunderstorm visits a town illuminated by electricity, photographers will, both in daylight and after dark, expose a few plates for the elucidation of the thoughts suggested to us. I say in daylight, for the camera will often record impressions that our eyes cannot see by reason of other external surroundings, as instanced by my noticing upon one occasion with the unaided eye a stream of electricity descending from an arc lamp towards the earth which I should assuredly have never seen had I not learnt from these photographs that such a phenomenon did exist.

SYDNEY WEBB.

Dover, October 1899.

I WISH to add a few remarks to Mr. Webb's description of the way in which his remarkable photographs were obtained, my object being to point out certain features which seem likely to lead towards an explanation of the discharges which take place, simultaneously with lightning flashes in the sky, in the neighbourhood of the electric lamps.

Fig. 1 represents a photograph which was taken looking westwards before the installation from the ornamental glow lamps was set up for the season. The three roundish luminosities represent the normal illumination due to four arc lamps. If these, taken in order along the street, be called Nos. 1, 2, 3, 4, their order in the picture, from left to right, will be 1, 2, 4, 3, but Nos. 3, 4 are so nearly in the same line of sight that the images of their normal luminosities are blended into one. The lamps are twenty-one feet above the ground, and the distance from lamp to lamp is about ninety-two yards. Towards the upper left is seen a flash of lightning in the sky. Simultaneously with the flash, electric discharges took place between the lamps and the ground, which are recorded on the photograph.

It is to be noted that though the lamp-posts were of iron the discharge did not take that course to the earth, but went in a curved path which must have been thirty feet or so in length. Its course led towards the high-tension cable, which ran underground along the esplanade; but whether the cable had anything to do with it, there is not sufficient evidence to show. The different paths are remarkably similar, almost identical in form. A striking feature of the discharge is its beaded or stratified character. The intensity of the discharge and the closeness of the stratification are both greatest near the lamp, and decrease as we approach the ground.

Another photograph (2*a*), not here reproduced, was taken under the same circumstances, but with a different flash. The general features are the same, but the form of the curves is different. Instead of a curve convex outward, as in Fig. 1, we have curves first convex, then concave, then convex again, and as in the former case similar to one another. The negatives of these show a feature which does not appear in the reproduction (Fig. 1), nor even in positives taken with sufficient exposure to show the fainter portions of the discharge. In the negative of 2*a*, the images of lamps 2, 3, 4 show each a pair of short straight dark lines, indicating special luminosity, like two "I's" parallel to one another and nearly vertical, the base of the right being nearly on a level with the top of the left. No. 1, which is much nearer, has too much darkened the negative to show more than a trace of one of the I's. The discharge in 2*a*, which shows the stratification, is seen issuing from the top of the right-hand upper I in a nearly horizontal direction. The negative of Fig. 1 shows a similar strong luminosity, only here the I's, if they are distinct, are nearly horizontal, and run one into the other. In this feature, again, we observe as before similarity from lamp to lamp, difference from flash to flash.

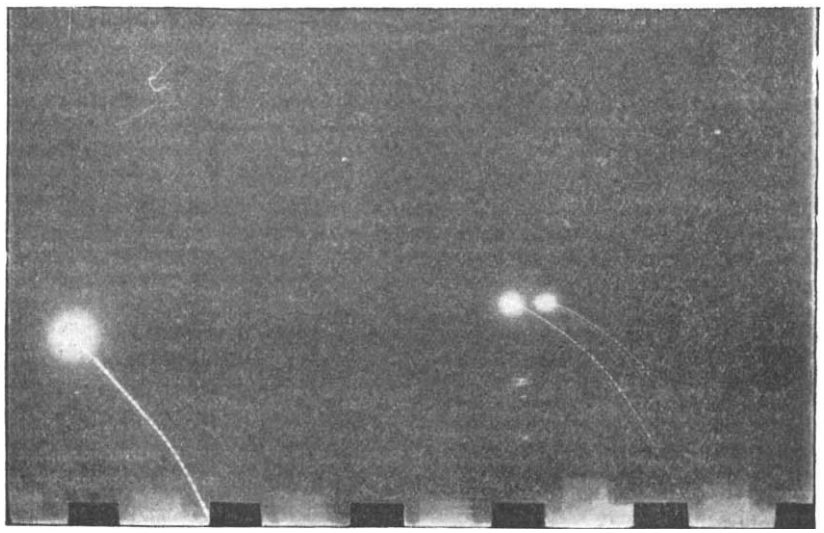

FIG. 1.

Four photographs were taken looking east along the shore. Three of these are here reproduced (Figs. 2, 3, 4). In one only of these is the flash, which gave rise to the discharges, seen in the field (Fig. 2).[1]

The three figures all show one arc lamp which is tolerably

[1] It should be mentioned that in this case, and in this case only, the flash was strengthened by hand on the back of the negative to make it print better, so that the picture of the flash cannot be altogether trusted as to minute details.

near, with the discharges connected with it, and the discharges belonging to several very distant arc lamps, of which five are seen to the right and a few to the left of the former. Fig. 3, which points a little more to the north, takes in an arc lamp at an intermediate distance. These figures, as before, point out very strikingly the similarity of the discharge from lamp to lamp, and the difference from flash to flash.

Thus, in Fig. 2, we have a nearly vertical discharge from the near lamp, and also from the distant lamps, whereas in Fig. 3 we have the corresponding discharges nearly horizontal, somewhat resembling parabolas in a horizontal plane. In these cases, unlike that of Fig. 1, there is a discharge of curious form which is more conspicuous than the discharge between the lamp and the ground.

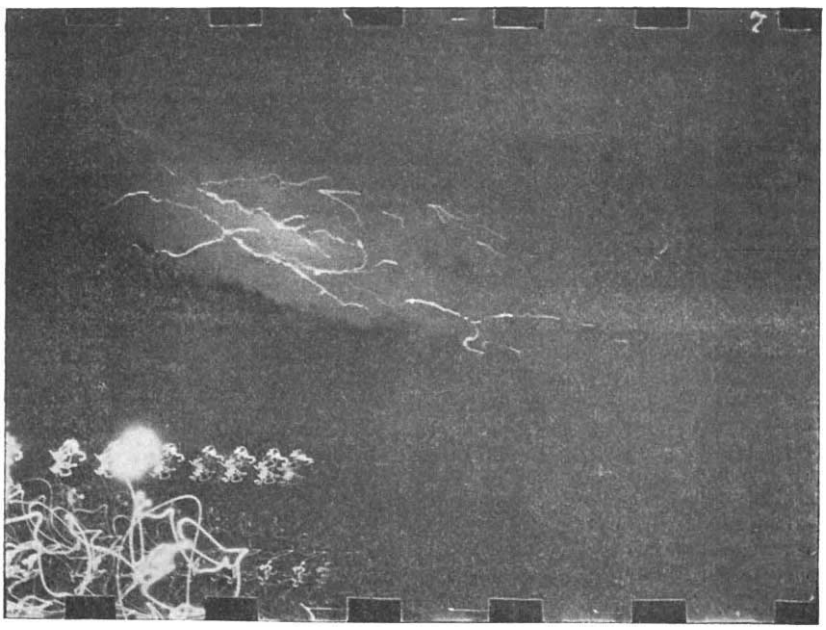

FIG. 2.

The finer beading naturally cannot be shown in the reproduction, though it appears in very many cases in the positive copies, and still better in the original negatives. After an examination of the actual photographs, one is disposed to regard the beading as a normal feature of this kind of discharge, though for different reasons it cannot always be traced.

Fig. 5 was taken towards the sea, facing the installation for ornamental incandescent lamps just opposite to Mr. Webb's house. The flash which occasioned the local discharges is seen in the field. Some luminosity is seen at the top connected with the mounting of the ornamental lamps, and delicate discharges going obliquely downwards. But the chief luminosity would seem to have relation to the high-tension cable below, and it may be also to one or both of the horizontal wires above, across which the lamps are hung, and which are charged through transformers to a much lower tension.

The complicated Fig. 6 represents five flashes, all apparently in the field, and the local effects due to them. At the risk of a digression, I would point out the character of one of the flashes —that shown in the middle of the field—though what I am about to say can hardly be gathered from the reproduction, but appears in a positive photograph, or, better still, in the original negative. The actual photographs give strongly the idea of a spark discharge, the path of which is the right-hand boundary in the picture, followed by a transverse flow, or arc-discharge, from right to left, all over the path of the spark; then a second spark-discharge, parallel to and less strong than the former, followed by a second transverse flow. Previous photographs taken with a moving camera had shown a duration of luminosity after the spark-discharge, which would naturally be interpreted to indicate either a sort of phosphorescence of the air, produced by the spark-discharge, or else an arc-discharge proceeding along the path opened up for it by the spark. But Mr. Webb's photograph, the original of Fig. 6, seems to indicate pretty plainly an arc-discharge proceeding, with a variable intensity, from the different points of the path of the spark, but flowing in a direction *transverse* to that path.

The local effects, which form by far the greater part of the luminosity represented in Fig. 6, are naturally very complicated, on account of the number of flashes; too much so to be convenient for individual discussion. We may notice, however, in a general way, the repetitions of the same form and the beading. A prominent object is the very formidable-looking discharge shown in the left half of the picture, traces of the beading of which may be seen even in the reproduction.

In several cases the photographs indicate pretty plainly a local discharge of the form of tape striped across. The tape in its course is liable to be bent or twisted, or both. In places where the plane of an element of the tape is in the line of sight, the striping is not usually seen, as the bright and dark stripes would overlap unless the axis of the tape happened to be roughly perpendicular to the line of sight.

In connection with the phenomena presented by the electric lamps in a thunderstorm, as revealed by the photographs, several theoretical questions present themselves. Do the lamps act merely in consequence of the tall iron lamp-posts, so that the effect would be the same if the dynamos at the works were not in action, or is the artificial electricity concerned in the production of the effects? What is the nature of the action of the flash of lightning in bringing about the discharges? What determines the course of the discharge, and why is it so different from flash to flash, while for a given flash it is nearly the same for lamps ranging over a space of some hundreds of yards? What is the nature of the beading or striation?

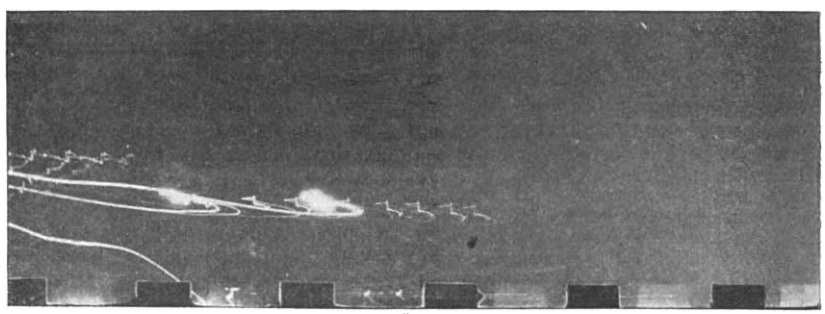

FIG. 3.

As the lamps are wanted for public lighting, the experiment could not well be made of disconnecting one from the works when a thunderstorm was impending in the evening, and seeing whether the one disconnected would give a discharge like the others. In default of experiment I can only say that from my theoretical notions I think that the electrical action of the lamps is required.

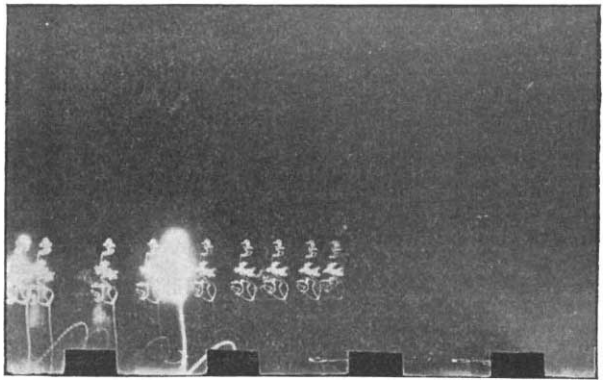

FIG. 4.

When the lamps are in use there is a very steep gradient of electric potential about them. I am informed that there is a difference of about 50 volts between the carbons of the Dover arc lamps, and this entails steep gradients in the air about them. If, then, there were something to cause a sudden change of potential-gradient irrespective of the lamp, this, when compounded with the normal gradient due to the working of the lamp, would give a gradient in some places greater and in some less than the normal. A path might thus be opened for a discharge different from the normal one from pole to pole, and this might pass away from the lamp altogether, and even go to the ground, provided there were a sufficient gradient to continue it when it had got to a distance from the lamp; and such a gradient might naturally exist in thundery weather. Or, again, if there were something to cause a sudden diminution in the resistance of the air, a similar effect might be produced.

The striking of a flash would no doubt be accompanied by a sudden change in the atmospheric electric potential. But I rather incline to the other view, and to regard the phenomenon as what I may call a case of Nature's wireless telegraphy. This view would make it depend on electromagnetic waves propagated from the flash. The flash would take the place of the sending instrument, the resisting air that of the coherer, the gradient of potential, whether artificial (that due to the electric works) or natural (that existing in thundery weather), would take the place of the electromotive force of the battery or cell which tends to send a current through the coherer, while the electromagnetic waves would open a path for the current in the air as in the coherer.

The close similarity of the discharges from lamps three hundred yards or more apart points to a distant cause, or at least one which is much the same at places 100 or 200 yards apart in a horizontal direction. This is not incompatible with the supposition that the path, when the discharge is fairly launched from the lamp, depends on the atmospheric variation of the atmospheric electric potential, which may very well be on an extensive scale; and such a similarity of path is what might have been expected beforehand if the paths depend on electomagnetic waves coming from the flash; and it may well depend on a combination of these two conditions. The difference from flash to flash would seem to be in this way most easily accounted for. For not only might different flashes, though close together in time, come from different parts of the sky, but even if they came from nearly the same quarter the mode of the transverse ethereal vibrations would be pretty sure to be different. Now the facility for the passage of a current afforded by an electromagnetic disturbance would naturally depend jointly on the direction of vibration and the direction in which the current tended to pass, that is, on two independent vector quantities, the pre-existing potential gradient and the ethereal vibration; and further, the vibration might very well resemble that in common rather than that in plane polarised light; so that there is abundant room for complexity, and for variation from flash to flash, as regards the path of the local discharge.

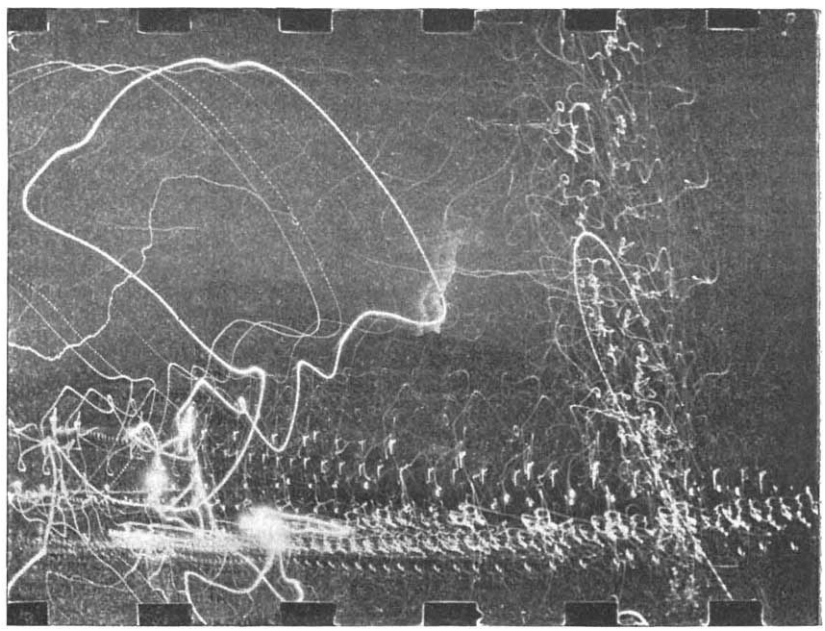

FIG. 6

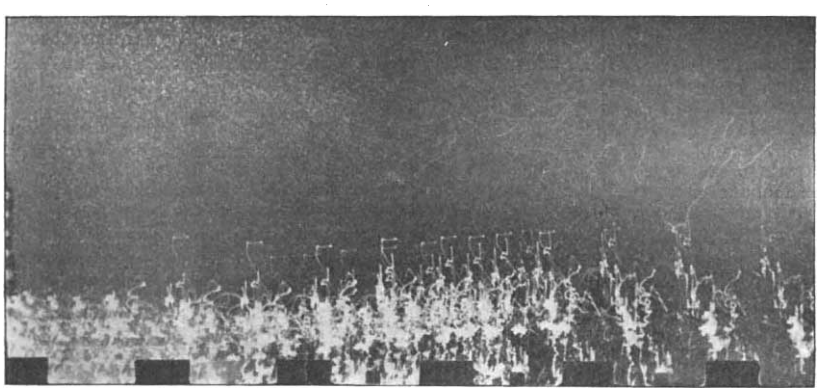

FIG. 5.

The striation or beading of the discharges remains to be considered. The Dover lamps are worked on the alternate current system, and it might at first sight be supposed that perhaps the beading may have something to do with the alternation. But, as was pointed out to me at the Dover electric office, this could not be. For the period of the current is about the hundredth of a second, and if we counted the beads we should arrive at a duration of discharge much too great

to be allowed. Two ideas presented themselves to my mind as to the possible origin of the beading. One was that it might have something to do with the way in which the path crossed a series of electromagnetic waves, like those of light, except as to the scale of wave-length. Another, which seems more probable, is that they are of the nature of the stratified discharge in exhausted tubes. This supposition indeed is not free from difficulty, though I do not think the difficulty fatal. In an ordinary tube it requires a very good exhaustion to get strata as much as an inch thick. But here, at full atmospheric pressure, we have strata a foot or more in thickness. However, in a Geissler tube the strata are closer in the capillary part, where the current is concentrated, than in the broad part. It may be that in the discharges, for example, represented in Fig. 1, which are unconfined laterally, these wide strata are possible, and if so, the density of the current is small. It has already been remarked that the intensity decreases as we go from the lamp to the ground. It seems that the current is gradually spent in electrifying the air. If this explanation be correct, the local discharges represented in Mr. Webb's photographs may not be so dangerous as some of them look. Still, until we know more about the subject, it might be prudent in a thunderstorm to keep a little away from arc lamps in a street.

If the wireless telegraphy theory which I have ventured to throw out be the true account of the Webb discharges, it seems that by imitating with any necessary modification the receiving apparatus, and introducing a telephone, as has been done with great advantage by M. Turpain in his researches, it might be possible simultaneously to see and to hear a flash of lightning.

Cambridge, January. G. G. STOKES.

The Mathematical Tripos.

ON February 15 the recommendations of the Special Board for Mathematics on the Mathematical Tripos will be voted on by the Senate of the University of Cambridge. With regard to the changes proposed in the general arrangement of the examinations there can be scarcely any difference of opinion. About twenty years ago the advances in mathematical science had reached such a pitch that it was impossible to cover the whole range of mathematics in a single examination, and many a promising mathematician found himself seriously fettered by the necessity of having to confine himself to those parts of the subject which would best enable him to obtain a high place in the examination, and to spend his time in attaining proficiency in rapidly solving certain classes of problems rather than devote himself to specialising in the higher branches of mathematics. It was under these conditions that the Tripos was divided into two parts, the first covering the less advanced subjects, and the second enabling a candidate to specialise in those portions of higher mathematics for which his enthusiasm and ability best qualified him. The further developments of the last twenty years have necessitated an extensive reconstruction of the schemes, and the framers of the present regulations have been at great pains to bring the Mathematical Tripos into line with modern requirements. At the same time it is becoming daily more and more evident to those competent to judge that a sound training in mathematical methods is of paramount importance in the study of applied science, and the regulation allowing candidates to take Part i. in their fifth term should prove of great value to those who wish to study mathematics as a preparation for the subsequent study of physics or mechanical science or even, nowadays, chemistry.

The abolition of order of merit in Part i. is a logical outcome of the fact that this part does not represent the highest knowledge of mathematics. In late years the title of Senior Wrangler, which is often regarded in the outside world as the highest honour which Cambridge can confer, has often been bestowed on men who have proved unequal to the task of securing the highest place in Part ii. The announcement that a lady had been placed "above the Senior Wrangler" caused the greatest excitement throughout the country; but the fact that on another occasion the only candidate who secured a first division in Part ii. was a lady passed almost unnoticed. Still, it cannot but be regretted that because the Senior Wrangler has not always subsequently proved himself the best man of his year, the University should contemplate altogether abolishing the old title of Senior Wrangler, and that even "wranglers," "senior optimes" and "junior optimes," may soon be a thing of the past. When the Tripos was first divided into two parts, one of the mathematical authorities best qualified to judge considered it desirable that the title of Senior Wrangler should be given to the best candidate in Part ii. This was not done, and hence the position of Senior Wrangler has for many years been an anomalous one, and we have been irresistibly drifting in the direction of abolishing the title altogether. But why should not the first division in Part ii. be called "Senior Wranglers?" The number who obtain a first division in any year is very small, often not more than two, and these are surely no unworthy successors to the senior wranglers of the past. Moreover, by this means the competition for place would be avoided, each candidate being judged on his merits irrespective of whether he was in a strong year or a weak one, and the present anomaly of the second or third or even lower wranglers in a strong year being better than the senior in a weak one would be obviated.

Such a proposal is not inconsistent with the changes in the examinations proposed by the Board. The plea for the retention of the old titles is no question of sentiment. The mathematical school of Cambridge has, under the "coaching" system, taken a unique position in the educational system of the country, and it is but right that Cambridge honour-men should retain the marks of distinction which at present distinguish them from graduates of modern Universities. These marks of distinction are well known to the world at large, and may enable their possessors to carry greater weight in insisting on the importance of providing efficient mathematical teaching in our schools, and adequate endowments for the mathematical schools of our provincial University Colleges. Too often these schools and colleges are controlled by councils and governors consisting of business men, with whom the name "Senior Wrangler" carries weight, but who only look to the "main chance," and who see no use in encouraging mathematics because they do not understand it and think it "unpractical." In encouraging the purely experimental side of science there is a danger of neglecting that training which is needed to enable logical conclusions and practical applications to be deduced from experiments. It is, therefore, important that the old titles should be retained, not only to enable their bearers to point out that they have been trained in the same school which has produced so many of our best physicists, including a Maxwell and a Kelvin, and has thus contributed so greatly to the advancement of Applied Science, but also to encourage others to submit to that rigorous mathematical training without the fruits of which even the most practical of "practical men" would soon come to a standstill. G. H. BRYAN.

Floating Stones.

THE correspondence on "Floating Stones" brings to my mind a phenomenon I often noticed about ten years ago, when my work caused me to spend a good deal of time on the upper reaches of the River Mersey, of patches of earth floating down the river on the surface of the water. This occurred during the early part of the ebb tide and on water obviously contributed by the river. I concluded that this earth was detached from the banks during the quiescent period of high water, and that the surface tension of the water was so increased by the strength of the effluents from the manufactories and other sources, that lumps of earth, often several inches in area and of appreciable thickness, were enabled to float. Unless the conditions have since changed, no doubt the same thing may still be observed.

Coopers Hill, February 3. A. W. BRIGHTMORE.

ENGINEERING AT CAMBRIDGE.

ON Friday, February 2, a large and important addition to the Engineering Department of the University of Cambridge was inaugurated by Lord Kelvin, as a memorial to the late Dr. John Hopkinson, and his son, John Gustave Hopkinson. In August 1898, only a few days before the terrible accident by which he lost his life, Dr. Hopkinson had discussed with Prof. Ewing the rapid growth of this department, and the urgent need for its extension, and had expressed his intention of starting a fresh movement among engineers to secure the necessary funds. In October of the same year, Mrs. Hopkinson communicated to the Vice-Chancellor of the University the desire of herself and her son and daughter to give